SFI Smart Ocean

Flexible and cost-effective monitoring for management of a productive and healthy ocean

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CONTENTS

• Industrial & societal challenges; Knowledge needs

• The SFI Smart Ocean initiative
OECD: The Ocean Economy in 2030

• “The ocean industries have the potential to double their contribution to the global economy by 2030”

• Norwegian industries - World leaders in Ocean industry, Technology, and Operations:
  – Oil & Gas
  – Aquaculture
  – Offshore wind

• Unique possibility for Norwegian industry:
  – Further develop Norway as a key ocean technology provider
  – Increased innovation and further international growth
OECD: The Ocean Economy in 2030

Emphasis:

- Measurement

- “The drive for miniaturization and automation, the growing demand for low-power, low-cost devices for the measurement and graphic display of the physical environment, and moves to endow the sensor itself with intelligence”
“Strengthening observation and monitoring capacities through enabling technologies, new platforms and sensors, addressing under-sampling and ensuring that new environmental parameters can be rapidly and accurately measured”
UN Decade of Ocean Science for Sustainable Development (2021-2030)

Objectives

• Generate the **scientific knowledge** and underpinning **infrastructures** and **partnerships** needed for sustainable development of the ocean.

• Provide **ocean science, data and information** to **inform policies** for a well-functioning ocean in support of all sustainable development goals of 2030 Agenda.
# National strategies

- Regjeringens havstrategi
- HAV21
- MARITIM21
- Digital21
- OG21

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SFI Smart Ocean - Application

- Norwegian Research Council (NFR)
- 20 Partners
- 8 years
- 285 MNOK

Ocean: Environmental monitoring
Installations: Condition-based maintenance
Consortium

RESEARCH PARTNERS:
- University of Bergen (UiB) [project owner]
- Western Norway University of Applied Sciences (HVL)
- NORCE
- Norwegian Defence Research Establishment (FFI)
- Institute of Marine Research (IMR)
- Nansen Environmental and Remote Sensing Centre (NERSC)

USER PARTNERS – INDUSTRY:
- NN1 – International O&G operator
- NN2 – International O&G operator
- Aker Solutions AS
- Kongsberg Maritime AS
- Xylem / Aanderaa Data Instruments AS
- Octio Environmental AS
- Tampnet AS
- Halfwave Subsea AS
- Metas AS
- Bouvet AS

USER PARTNERS - INDUSTRY CLUSTERS:
- GCE Ocean Technology
- GCE NODE Service AS

COOPERATION:
- VIS [formerly Bergen Technology Transfer (BTO)]
- Norwegian catapults and infrastructure

USER PARTNERS – PUBLIC
National (regulating) authorities:
- Directorate of Fisheries
- Petroleum Safety Authority Norway
SFI Smart Ocean

Prime objective:

Wireless distributed network system of autonomous smart sensors for multi-parameter monitoring of underwater environments and installations.
SFI Smart Ocean - Key elements

SENSOR TECHNOLOGY / MEASUREMENTS:
• Autonomous & Intelligent sensors
• Rechargeable battery operation
• Low power (local "intelligence")
• Acoustic modem interfacing
• Robustness & Accuracy
• Anti-biofouling surfaces
• Data safety
• Cost-efficiency

MEASUREMENT STRATEGIES:
• Flexibility (size, location)
• Stationary platforms / No cabling
• Retrofit
• Adaptive sampling
• Time series / history
• Measurement strategies
• Uncertainty (requirements, sensor)

COMMUNICATION
• Wireless sensor network
• Underwater (acoustic) & Air (5G, satellite)
• Standardized protocols (vendor invariant)
• Low power
• Reliability
• Cost-efficiency

SOFTWARE & DATA MANAGEMENT:
• Embedded data compression
• Two-way communication
• Local (embedded) "intelligence"
• Big-data handling
• Data storing / format
• Analysis / Machine learning / Prediction
• Data aggregation
• Data safety
• Reliability

OVERALL OBJECTIVES:
• Sustainable ocean industry operations
• Fact-based ocean management
Stakeholders and End users

- Oil and gas operators
- Offshore wind farm operators
- Aquaculture industry
- National (regulating) authorities:
  - Norwegian Environment Agency
  - Petroleum Safety Authority Norway
  - Norwegian Directorate of Fisheries
  - Norwegian Coast Guard
  - Kartverket

- Technology providers (manufacturers, vendors)
Oil & Gas: Monitoring
- Pipelines
- Subsea production systems
- Installations
- Environment

Environmental (examples)
- Pressure
- Temperature
- Salinity
- Currents: direction, strength, profile
- Turbidity
- CO₂ concentration
- O₂ concentration
- pH value
- Chemical substances
- Oil-in-water
- Seabed ecosystem
- Seabed gas leakage
- Noise

Facilities:
- Pipelines, Process & Installations (examples)
  - Flow-induced vibrations
  - Safety valves: condition
  - Pipe leakage
  - Pipe integrity
  - Process integrity

OBSERVATIONS:
- Autonomous & intelligent sensors
- Battery / Rechargeable
- Wireless sensor network
- Stationary platforms / No cabling
- Retrofit installation / operation
- Adaptive sampling possibilities
- Time series / History
- Automatic analysis / Machine learning
- Warning signal:
  ➔ Decision making / Intervention

Onshore Asset Control Room

Mobile network or Satellite

Stationary Sensor Network

Pipelines

Seafloor AUV/UID station

Flow-induced vibrations

Safety valves: condition

Pipe leakage

Pipe integrity

Process integrity

Decision making / Intervention
Offshore wind farming: Environment & Structures

**Structural (examples)**
- Structural vibrations
- Anchor wire stretch
- Cement grouting integrity

**Environmental (examples)**
- Currents: direction, strength, profile
- Waves: height, profile, direction
- Noise level & Consequences

**MONITORING:**
- Autonomous & intelligent sensors
- Battery / Rechargeable
- Wireless sensor network
- Retrofit installation / operation
- Adaptive sampling possibilities
- Time series / History
- Automatic analysis / Machine learning

**Warning signal:**
- Decision making / Intervention

**USV**
- Mobile network or Satellite

**HUB**
- Stationary Sensor Network
Offshore wind farming: Environment & Structures

Integrated wind farm situation (Overview):
- Individual turbine situation ➔ Complete farm overview
- Data/trend analyses / Machine learning / Prediction
- Sensor drift ➔ Compensation methods

Sheringham Shoal Offshore Wind Farm, UK (Equinor)
Environmental

- Pressure
- Temperature
- Salinity
- CO$_2$ concentration
- O$_2$ concentration
- pH value
- Chemical substances
- Currents: direction, strength, profile
- Waves: height, profile, direction
- Turbidity
- Seabed ecosystem
- Salmon lice: concentration, spreading

Life

- Chemical substances
- Salmon lice: concentration, spreading

Aquaculture: Environment

OBSERVATIONS / INTERVENTION:

- Autonomous & intelligent sensors
- Battery / Rechargeable
- Wireless sensor network
- Retrofit installation / operation
- Adaptive sampling possibilities
- Time series / History
- Automatic analysis / Machine learning
- Data storage: interfacing to AquaCloud

- Warning signal: ➔ Decision making / Intervention

SMART OCEAN FUTURE

Mobile network or Satellite

Control Room

Stationary Sensor Network

HUB

USV
Integrated fish farming situation (Overview, Environment):
• Individual farm situation ➔ Company overview
• Company level
• Data/trend analyses / Machine learning / Prediction
• Data storage: Interfacing to AquaCloud

- Temperature
- Salinity
- O2 concentration
- Turbidity
- Etc.
Integrated fish farming situation (Overview, Environment):
- Local measurements + Simulations ➔ Regional overview
- Company level
- Intercompany level
- Data/trend analyses / Machine learning / Prediction
Dersom en skal kunne få pålitelig kunnskap om status og endringer i havets “helsetilstand”, lokalt og globalt,
så må en ha målinger av kritiske oseanografiske parametre, over tid, for havområder, kystområder, fjorder, havner og industrilanlegg.
Dersom olje- og gass-industrien skal kunne realisere sine visjoner om utslippsfrie autonome subsea produksjonsanlegg,
så må en ha et nettverk av stasjonære sensorer,
på kritiske lokasjoner,
som kan gi alarmsignal, før noe går galt.
Research partners: Scientists solving real challenges

Examples of commercial products
Research partners: Scientists solving real challenges

Examples of spin-off companies

Offshore Sensing AS
its Learning
XSENS Flow Solutions
Inside Reality AS
NORCE Western Norway University of Applied Sciences
NERSC Norwegian Defence Research Establishment
Universities of Bergen
FFI Forsvarets forskningsinstitutt
NERA
AANDERAA
Michelsen Medical AS
SFI Smart Ocean
UNIVERSITY OF BERGEN
Consortium

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